3 mm Microduct System for FTTH Networks in MDUs

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Abstract

When installing fiber to the home (FTTH) in Multi Dwelling Units, the challenge is to reach all apartments in the most convenient and cost effective way. Traditional drop cable solutions have several drawbacks such as high installation cost due to extensive fiber splicing. Air Blown Fiber (ABF) technologies using 5mm micro ducts where fiber is blown-in, offers splice-free installation at low cost, but also present problems with large cross sections in narrow risers.

This article presents results from practical and theoretical studies regarding 3mm ducts for air blown fiber installations in indoor environments.

3mm duct assemblies have been manufactured and tested in lab environment and at customer field trials. The results show that a 3mm duct system is an excellent option for indoor installations and offers huge benefits.

The tiny 3mm duct system combines the benefits of low-cost splice free installation of air-blown fiber with slim size, suitable for installation in narrow risers.

Keywords: Fiber to the home; FTTH; Fiber access; microducts; microducts; Air blown fiber; Indoor installations; EPFU; Drop network;

1. Introduction

Air blown fiber in 5mm microducts has been used for several years to minimize installation cost of FTTH networks. One of its main benefits is that the technology offers an installation process with a minimum number of costly fiber splices and a future proof infrastructure in a way that a riser/drop cable solution of any type cannot match. However, in Multi Dwelling Units, there are some few but important drawbacks with air-blown fiber compared to traditional cable solutions. The larger cross section of the 5mm ducts and duct assemblies may cause a higher cost of installation due to limited space in risers. This results in the necessity of finding alternative routes or use costly core drilling. Also the visual impact from exposed ducts in public areas could be an issue.

One possible way to address the above is to decrease the diameter of the ducts to a minimum without violating the performance of the system. The impact of smaller ducts will be presented in more detail in the following sections.

Today, the vast majority of all air-blown fiber installations in Europe are carried out with 5mm ducts. Previously, 3mm duct systems have been used for outdoor installations but have now been abandoned by most customers. The reason for this is that the blowing performance (installation length) for outdoor environments usually requires 5mm ducts. In addition to this, there are not much cost savings in using compact 3mm bundles for outdoor environments.

For indoor installations, the situation is very much the opposite; Long installation distances are not required, but the cost of installation is affected by the diameter of the duct bundles. The reason why 3mm ducts are not yet provided for indoor installations to greater extent is most likely that the material used for traditional indoor ducts is too soft (polyolefin with flame retardant substances), and the soft material cannot easily be formed into 3mm ducts that will not collapse during production or installation.

In this study, 3mm duct assemblies made from hard HDPE are used. To achieve sufficient flame retardant properties, they are provided with a flame retardant sheath of polyolefin.

By reducing the diameter from typically 5mm to 3mm the cross section is reduced by 64%. Therefore existing narrow risers can be used and costly core drilling is avoided.

The 3mm system has been verified in field trial installation in the city of Hudiksvall, Sweden and a pilot case in Geneva, Switzerland. The results show substantial cost savings of approximately 23%. In addition to this, the total savings are even bigger considering the smaller size and weight when it comes to handling, storage, shipping etc.

Even when the diameter is reduced, mechanical tests show promising results that meet or exceed the applicable IEC recommendations. Installation performance tests have been carried out in a very challenging 300m long test track that simulates the worst possible installation conditions. The trials and tests shows that the technology is stable and provides substantial cost benefits for MDU installations compared with other cabling alternatives.

2. Theory and Background

2.1 Cost of Materials

The cost of materials is normally not an issue since the current 5mm system for air-blown fiber is in the same magnitude as any premium drop cable solution on the market. In addition to this, the splice-free installation with Air-blown fiber enables lowest total cost (including installation). However, in some markets, it is hard to argue with complex “Total Cost of Ownership” models and customer are still comparing materials cost by “bits and pieces”.

This issue has recently been addressed by the introduction of low-cost indoor 5mm duct systems series of flame retardant ducts with a limited fire resistance according to IEC60332-1. For markets without requirements on fire resistance even HDPE used for outdoor applications may be used.

The market acceptance for indoor ducts with a slightly lower, but still sufficient fire resistance classification opens up the options for new types of ducts such as the 3mm duct system manufactured with HDPE and with a flame-retardant sheath.

In theory, the cost of materials for 3mm ducts should be lower than 5mm ducts since less material is used. This statement will be analyzed further in the following sections.

2.2 Cost of Installations

In many brownfield scenarios, e.g. buildings without existing risers or risers with limited space, there is a risk that the savings in installation cost of a splice-free Air-blown fiber system will cancel out compared to a drop cable system.

A drop cable solution with slim riser cables may be possible to install in existing risers whilst 5mm microduct bundles are not. For ABF, additional, wider risers may be required with costly drilling between floor levels.

In those cases, core drilling (large core diameter drilling) between floor levels with installation of new raceways may be required. Chopping is another option that is equally time-consuming.

Figure 1. Core drilling

Core drilling is used with water cooling so there is a setup time for water feeding and water removal. To avoid expensive core drilling, the customer needs to find alternative solutions. A few possible solutions for the traditional 5mm ABF are:

- Installation of new risers on the façade of the building
- Use other types of risers such as elevator shafts, garbage shafts etc
- Use single ducts, blow in 8-fiber units (EPFU) in vertical risers and splice to single fiber ABF on each floor

All of the above solutions will not be applicable in all situations. The third case will address the problem of narrow risers, but limit the flexibility of the system and also add a costly splice point on each floor level. The use of a traditional drop cable solution may therefore be more appealing.

However, individual drop cables may be slimmer but this is not always the case. Another drawback may be that slim drop cables are easy to damage during installation. Even if a whole bundle can be pulled at the same time, the individual drop cables often lock together or create a mess when the last distance are to be adjusted. If the drop cables are pre-connected in both ends there is also again a cross section problem when pulling the cable trough narrow risers.

The other alternative to minimize the cross section is to use a micro-cable containing many fibers in the risers. The drawback of this of is that the cable needs to be opened several times and branched at different floor levels and then fiber spliced. Some drop cable solutions have tailor made drop cable assemblies already branched with connectors. This solves the splice problem but introduces a nightmare of site survey logistics and, again, cross section problems with the connectors.

A way to enable installation of microducts that will fit into tight risers should therefore be very important. The obvious way forward is to minimize the diameter of the ducts themselves so that they have the same diameter as traditional riser cables.

2.3 Visual Impact

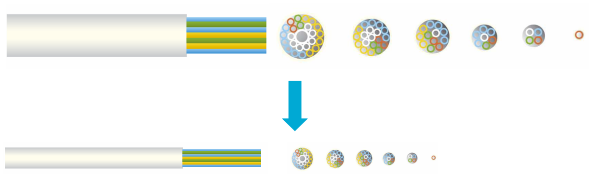

Figure 2. Reduced size and visual impact

Ducts are installed directly on walls, or placed in plastic or aluminum risers. Exposed large duct assemblies will not look good and, if covered by raceways, these will be quite large. It is therefore proposed that duct assemblies will be as small as possible to minimize the visual impact.

2.4 Performance Requirements

It is not realistic to expect similar installation distances in 3/2mm duct as in 5/3.5mm ducts. For indoor installations the average installation length is short, approximately around 50m in Europe and around 100m in larger MDUs like in Asia.

To be able to cover 99.99% of all installations in high rise buildings, the target blowing distance was set to at least 200m or preferably 300m. The outcome was measured at the indoor test track in Hudiksvall (to be described later).

3. Design and System Solutions

3.1 Microducts

3mm duct (inner diameter 2mm) has been used for many years for outdoor installations. This means that suppliers of suitable microduct connectors already exist. This dimension was therefore chosen for test and verification.

A 3mm duct assembly gives a cross section of only 36% of a 5mm duct assembly see Figure 3.

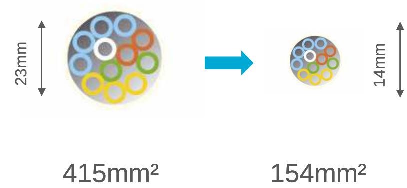

Figure 3. Comparison of 5mm and 3mm duct assemblies

Indoor ducts are traditionally made of halogen-free polyolefin material. Some manufacturers also use PVC (contains halogens). Because these materials are too soft, they cannot easily be formed into rigid 3mm ducts that will not collapse during production or during installation.

The previously introduced 5mm flame retardant HDPE duct assemblies (HDPE microducts with a sheath of flame retardant material) was the natural choice to propose for the rigid 3mm duct systems that still will be able to be classed as fire retardant according to IEC60332-1.

HDPE is therefore the proposed material for the microduct. The sheath will be of flame retardant polyolefin.

3.2 Connectors and Other Accessories

Two suppliers of microduct connectors were tested. A reduction connector that enables 3mm ducts to be joined to 5mm ducts was also tested. A reduction connector may be useful when connecting an indoor environment with 3mm ducts together with existing 5mm outdoor ducts.

Other types of accessories or modifications to existing products such as duct holders for cabinets are also to be taken into consideration for the system. One straightforward solution is to increase the diameter of the 3mm duct with a piece of 5mm duct so that existing duct holders can be used. This technique was used for the field trial.

4. Results

4.1 Manufacturing of Ducts

3mm HDPE microducts were bundled to form 2000m of a 7-way microduct assembly. The sheath was somewhat hard to remove, but no problems were reported from the field trial, see following sections. In a full-scale production the inner layer of the sheath may require longitudinal grooves to facilitate removal.

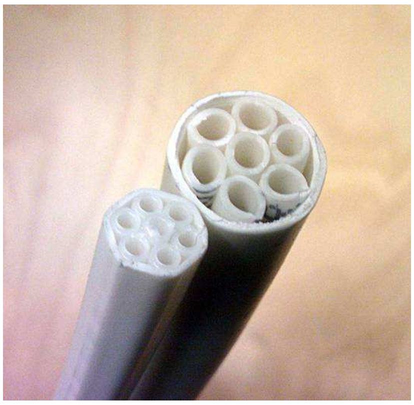

Figure 4. 7x3/2.1mm compared to 7x5/3.5mm assembly

4.2 Cost Savings

A single 3mm duct contains only 39% of the amount of materials compared to a 5mm duct (approx 40-50% for a duct assembly). It is therefore expected that the cost of ducts will be lower. Due to manufacturing reasons, the smaller ducts need to be processed in a controlled speed. Initially, the cost savings on the materials may be cancelled out by lower processing speed, but potentially the cost may be lower.

Cost savings on the materials is not a driving force for the introduction of 3mm ducts.

Cost savings are hard to predict since the installation environment varies, but to get a view of potential savings the following case study is used:

- A multi dwelling unit with 6 floors and 24 apartments
- Typical total cost of installation, excluding core drilling, is assumed to be 70 USD per apartment (including materials)
- Core drilling for 5 holes is assumed to be 500 USD (machine and tool wear 150 USD, labor 5h, 70 USD/h)
- As a rule of thumbs, core drilling can be avoided when the diameter of a hole is 20mm or less

If core drilling can be avoided by using existing risers, the cost of installation will be 500 USD lower (21 USD/apartment). This corresponds to a saving of 23% of the total cost.

In real-life situations, the savings with 3mm ducts can be even larger:

- It may be possible to avoid drilling at all using existing risers
- The size and cost of covers for external risers will be significantly lower
- Handling and shipping cost of ducts can be reduced by more than 50% (64% reduction in volume, 50-60% reduction in weight)
- Packaging density of fiber access terminals or fiber distribution hubs can be increased, enabling lower cost

4.3 Performance Tests

4.3.1 Drum Test

To get a baseline for verifying performance of 3mm ducts, several drum tests according to the BT standard test and the IEC draft were performed. For test descriptions, see ref. [1] and [2].

The BT test is developed for 5mm ducts and specifies a cable drum with a belly diameter of max. 509mm. This drum shall contain 500m duct and a blown fiber must be able to be blown trough the reel within max 21 min. Since it is not possible to blow trough a fiber in a 3mm ducts on a reel of this type, a more suitable verification test was proposed and used.

Figure 5. Drum test

It was decided to use the same type of reel with the same acceptance criteria (max 21min), but limited to only 300m of duct. The 300m distance is well within the maximum distance used for blowing of fiber in indoor installations.

When testing, a fiber unit with 1-4 fibers was blown trough in 19 min 57 sec. Note that typical installation distances for MDUs (50m) was blown in 2 min 37 sec.

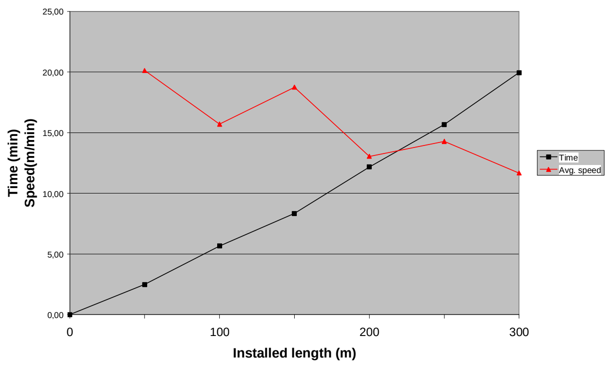

Figure 6. Drum test – Installation time and speed

4.3.2 Indoor Test Track

The drum test as described above is mainly used as a benchmark test to verify product performance relative to other products. To simulate a more realistic installation environment, Ericsson uses a standardized test track with 16x90° turns.

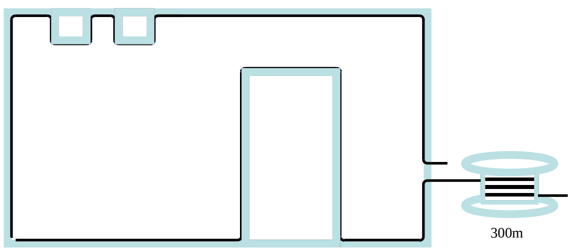

Figure 7. Indoor test track lay out

To simulate worst possible real life conditions, the test track was connected to a reel of 300m of ducts. This highly unlikely scenario was used as the reference for verifying the technology.

The fiber was blown trough the test track in 29 min 40 sec. Again, a typical installation distance of 50m was blown in 2 min 48 sec.

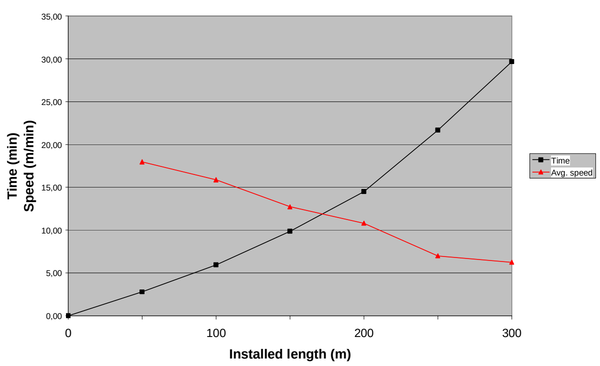

Figure 8. test track – Installation time and speed

4.3.3 Crush Test

To withstand forces during installations in narrow risers, a high crush resistance is required. In this study, a comparison of the crush resistance of a traditional 7-way indoor microduct assembly and the 7-way 3mm assembly was carried out. The duct assembly is being crushed and the deformation of the duct is measured. In addition to this, an inner clearance test is performed using a metal sphere with a diameter of approx 85% of the inner diameter of the duct.

According to IEC [2], a maximum deformation of 15% is allowed at 450N. It was expected that the ducts would exceed the IEC specifications so tests were therefore performed at 1500 and 2200N. The results at 1500N are shown in Table 1 below: The tests performed at 2200N resulted in very low deformation (≤4%), but the inner clearance test failed on one out of 21 microducts.

	5mm Multiduct Assembly 7-way (MPB30209/7)			3mm Multiduct Assembly 7-way		
Force	1500 N			1500 N		
Sample	1	2	3	1	2	3
Diameter Before (mm)	18,60	18,25	18,27	10,81	10,80	10,86
Diameter After (mm)	18,04	17,92	17,02	10,47	10,46	10,40
Defomation (mm)	0,56	0,33	1,25	0,34	0,34	0,46
Deformation (%)	3,0%	1,8%	6,8%	3,1%	3,1%	4,2%
Inner Clearance (mm)	2,9	2,9	2,9	1,5	1,5	1,5
Inner Clearence Pass Trough	100%	100%	100%	100%	100%	100%

Table 1. Crush test comparison

As seen from the table, the 3mm microduct assembly has a very low deformation at 1500N and 100% of the metal spheres passed trough. The results also show that, as expected, the assembly exceeds the IEC requirements by far. The deformation is also in the same magnitude as the current 5mm microduct assemblies.

4.4 Flammability Test

Sheathed duct assemblies containing 1, 7 and 12 microducts was tested and passed the IEC60332-1 flammability standard.

As an alternative to the flame retardant sheathed single duct, an unsheathed and therefore non-fire resistant slim duct may be used. This duct needs to be installed in existing protective tubes of metal or other flame retardant material. The typical application for this duct is for the horizontal installation from the branch on each floor level to the apartments. The local fire regulations need to be considered in this case.

4.5 Field Trials

One field trial and one pilot installation were performed.

The field trial was done at Tullstugan, owned by Hudiksvallsbostäder a property owner in the city of Hudiksvall, Sweden. 2000m of the 7-way duct assembly and 1000m of single 3mm ducts were used for a field trial. The property is a typical multi dwelling unit built in 1968 and with limited available space for ducts. The purpose of the field trial was to gather information from the installation crew and also to observe any unexpected problems such as squeezed ducts etc.

Approximately 50 apartments were connected.

Figure 9. Field trial bulding, Hudiksvall, Sweden

An interview session with the contractor (Sörens El) was carried out after installation. Their opinion was that there is significant cost savings using 3mm ducts mainly due to existing narrow risers can be used instead of installing new risers or drilling larger holes in existing risers. The trial was carried out without core drilling.

A larger pilot installation case was carried out in Geneva, Switzerland in a 15 story high building (Le Lignon) containing 84 stairways, one of the largest residential buildings in Europe. The customer SIG (Electrical and telecom network owner) wanted to test the system in one riser to confirm if this was the most beneficial method to use for the rest of the building.

Figure 10. Field trial building

The setup was to use 2x12 + 1x7-way duct assemblies to different floor levels of the building. An unsheathed duct where thereafter installed in existing riser ducts to the fiber termination box. A fiber unit was blown to the ground level, approx. 50 m, in less than one minute. The installers anticipated no problems with the system and not a single hole needed to be drilled. Also here the perception was extensive cost savings compared to alternative methods.

4.6 Conclusions

Manufacturing and bundling of 3mm ducts into microduct assemblies is feasible and meets or exceeds the expectations on the performance of the system.

The primary indications show substantial savings for installation in indoor environments. The theoretical example and field trials show savings of at least 23% for a typical brown field MDU with no available risers. Cost savings on materials are considered small or negligible.

Two types of blowing verification tests, drum test and indoor test track were defined. Blowing performance tests gave values exceeding the target and was above expectations. Even tough blowing tests on reel show that it is possible to blow longer lengths than 300m in real life situations, the recommended typical maximum blowing distance was determined to be 300m. The typical blowing time in small to medium sized MDUs is less than 3min, which is in the same order as the existing 5mm duct system.

Crush tests show that the 3mm duct assembly is comparable in strength with a 5mm assembly and exceeds the IEC specifications.

Installation test carried out in field trial was successful without any reports on damaged ducts or any other problems.

The 3mm duct system allows easy integration with the existing standard 5mm duct system, however the total installation length in a combined 5mm and 3mm system may be reduced and need to be investigated further.

The 3 mm duct system is easy to adapt to existing Fiber Termination boxes, Fiber Access Terminals and Fiber Distribution Hubs and require only small changes or supplements to the duct holders

5. Acknowledgments

Special thanks to the installers at the field trials in Hudiksvall and Geneva that so patiently let our R&D people participate and evaluate their findings.

6. References

[1] CW1574 BT Specification for Enhanced performance Fiber Unit

[2] IEC 60794-5-20 Optical fiber cables Part 5-20: Family specification for outdoor microduct fibre units, microducts and protected microducts for installation by blowing

Authors

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